



# CS305: Computer Architecture

## The Iron Law

<https://www.cse.iitb.ac.in/~biswa/courses/CS305/main.html>

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# Performance: Time (Iron Law)

Time/Program =

Instructions/program X cycles/instruction X Time/cycle

Source code

ISA

microarch.

Compiler

microarch.

technology

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# Performance: Time (Iron Law)

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Instructions/program X cycles/instruction X Time/cycle

$(\sum IC(i) \times CPI(i)) \times \text{Time/cycle}$

# Example

Program p = one billion instructions

Processor takes one cycle per instruction

Processor clock is 1GHz

$$\begin{aligned}\text{CPU time} &= 10^9 \text{ instructions} \times 1 \text{ cycle/instruction} \times 1 \text{ ns} \\ &= 1 \text{ second}\end{aligned}$$

# Example

Program p = one billion instructions

Processor takes one cycle per instruction

Processor clock is 4 GHz

$$\begin{aligned}\text{CPU time} &= 10^9 \text{ instructions} \times 1 \text{ cycle/instruction} \times 1/4 \text{ ns} \\ &= 0.25 \text{ second (4X faster)}\end{aligned}$$

# Example

Program p = one billion instructions

Processor processes 10 instructions in one cycle

Processor clock is 4 GHz

$$\begin{aligned}\text{CPU time} &= 10^9 \text{ instructions} \times 0.10 \text{ cycle/instruction} \times 1/4 \text{ ns} \\ &= 0.025 \text{ second (40X faster)}\end{aligned}$$

# Example (Role of compiler/programmer)

Program p = one million instructions

Processor processes 1 instruction in one cycle

Processor clock is 4 GHz

$$\begin{aligned}\text{CPU time} &= 10^6 \text{ instructions} \times 1 \text{ cycle/instruction} \times 1/4 \text{ ns} \\ &= 0.00025 \text{ second (4000X faster)}\end{aligned}$$



# A bit deeper

Program p has 10 billion instructions

- \* 2 billion branches (CPI of 4)
- \* 3 billion Loads (CPI of 2)
- \* 1 billion Stores (CPI of 3)
- \* Rest 4 billion, arithmetic instructions (CPI of 1)

Clock rate 4GHz, What is the execution time?

Which one ?

Processor IMTEL: CPI 2, Clock rate 2GHz

Processor AND: CPI 1, Clock rate 1GHz

Assume compiler/ISA/... are the same.

IMTEL:  $2 \times 0.5 \text{ ns} = 1 \text{ ns}$  per instruction

AND:  $1 \times 1 \text{ ns} = 1 \text{ ns}$  per instruction 😊

Merci